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Annosus Root Rot in Eastern Conifers

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The fungus *Heterobasidion annosum* (Fr.) Bref. (= *Fomes annosus* (Fr.) Karst.) causes a root and butt rot of conifers in many temperate parts of the world. The decay, called annosus root rot, often kills infected conifers; infected trees that survive grow more slowly and are susceptible to windthrow and bark beetle attack.

This disease occurs throughout much of the Eastern United States, but is most common and severe in the South, probably because of differences in climate or susceptibility of native tree species or both.

The fungus usually enters a healthy stand by infecting freshly cut stump surfaces, which makes annosus root rot a problem primarily in thinned pine plantations.

The fungus infects many species of conifers. In the East, annosus root rot occurs on jack, loblolly, longleaf, pitch, pond, red, sand, shortleaf, slash, Virginia, and white pines. It is a major cause of death of eastern redcedar. Slash and loblolly, the most commonly planted species of southern pine, are very susceptible to this

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disease. Annosus root rot also has been reported to infect several hardwood species, though hardwoods appear to be much more resistant than conifers.

Signs and Symptoms

The fungus produces fruiting bodies, called conks, that have light-gray to dark-grayish-brown or reddish-brown upper surfaces. The undersurfaces of conks are creamy white, but become dark brown with age. The small pores on the undersurface produce sexual spores, or basidiospores, which are responsible for most of the spread of the disease from one stand to another. Conks are perennial, but often deteriorate after a short time and thus can appear to be annual.

Conks range in size and shape from very small buttons one-eighth inch (0.3 cm) in diameter to brackets several inches long. They form at the root collar (cover photo), on roots of living or dead trees, on stumps, or on slash. Matlike conks sometimes form in the needle litter. These conks are irregular masses of fungus tissue and imbedded needles. When they occur at some distance from an infected tree or stump, an attachment to a superficial root can usually be detected. Because conks are characteristically found at or below the ground line, the duff at the base of the tree must often be removed to see them. They can be easily overlooked because of their inconspicuous color and obscure location.

Conks may be abundant in some stands and scarce in others. Fresh conks are most common during late autumn and winter in the South, but may be present all year in the Northeast.

Heterobasidion annosum causes a decay of the roots and butt of an infected tree. An irregular, pinkish to dull-violet stain and pitch-soaking may indicate incipient decay. Narrow, elongated, whitish rot pockets then appear. These rot pockets sometimes have black spots or flecks. The narrow pockets finally run together and reduce the wood to a light-yellow, stringy mass of decayed tissue. The characteristics of this rotted wood are best seen in broken roots of windthrown trees. These roots are often shredded and stringy at the break (fig. 1), in contrast to the sharp, firmly splintered breaks of sound roots.

Pines in advanced stages of root infection can sometimes be recognized by the thin appearance of their crowns. The crowns have short needles and lose all but the current year's foliage. Annual growth of twigs is reduced. However, infected trees often do not show these symptoms; trees with extensive root rot may have full, green crowns.

The pattern of group killing by annosus root rot closely resembles that of bark beetle killing; careful examination is necessary to distinguish between the two. Furthermore, trees weakened by annosus root rot may attract certain bark beetles, and both the fungus and bark beetles may be present in the same tree. Conks—the fruiting bodies of the fungus—and pitch tubes and frass—evidence of bark beetles—on the same living tree suggest that root rot develops first and that bark beetles follow. This insect and disease association is common in the South.

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Figure 1—*The typical, stringy rot caused by* Heterobasidion annosum *in a loblolly pine.*

Means of Spread

The fungus usually enters a healthy stand by infecting freshly cut stump surfaces. Airborne basidiospores of the fungus land on a stump's surface, germinate, and produce filaments (mycelia), which colonize the stump and its root system. The fungus then spreads to adjacent trees by root grafts or contacts (fig. 2).

Further tree-to-tree spread by root contact usually results in a more or less circular infection center that may include 50 or more trees. After a stand is thinned, the process of infection of stump surfaces, spread through the roots, and death of the remaining, previously healthy trees may occur within 2 years.

However, stump infection does not always lead to infection of residual trees. Apparently, the fungus is unable to spread from root to root in certain soil types. In the southern Piedmont, for example, where soils are predominantly heavy clay, stump infection is common in thinned, natural stands; but living trees are seldom infected.

Because the fungus spreads primarily by infecting stump surfaces, annosus root rot is more prevalent in thinned stands. Here, where the fungus is abundant, trees can also be infected at fusiform rust cankers near the ground line. The roots of suppressed or weakened trees can be infected directly by basidiospores washed into the soil. Conidiospores of *Oedocephalum*, which is the asexual stage of the fungus, also may be involved in the direct infection of roots.

Damage

Annosus root rot damages pines in several ways—most obviously by killing them outright. Groups of trees or single trees scattered throughout a stand may be killed (fig. 3). Mortality

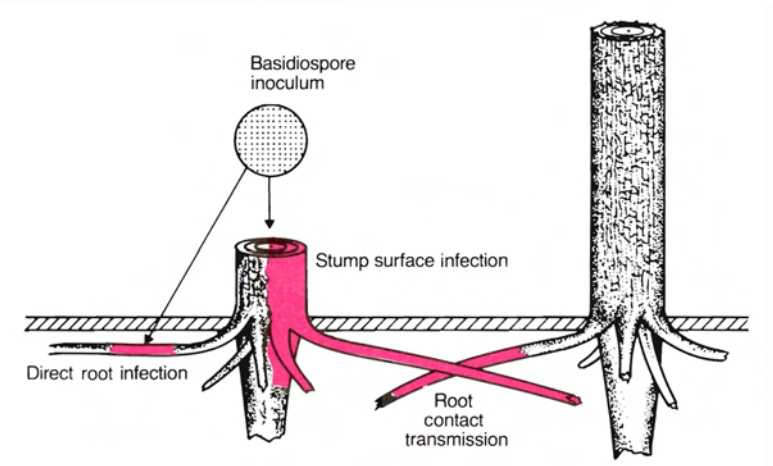

Figure 2—*Airborne basidiospores land on a stump, germinate, and produce mycelia that grow through the stump's roots. The disease is transmitted when the roots of adjacent residual trees come into contact with the infected roots. In thinned stands where annosus root is prevalent, basidiospores may infect the roots directly.*

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Figure 3—*A group of pines killed by annosus root rot.*

varies considerably from one plantation to another. In severely affected stands, as many as 30 percent of the trees can be killed by annosus root rot. Pines with extensive root rot can be blown over by the wind (fig. 4).

In addition to tree mortality, annosus root rot reduces diameter and height growth. In a 25-year-old slash pine plantation in Georgia during the 6 years following thinning, trees with more than 50 percent of their roots infected lost 40 percent of their height growth and 20 percent of their cross-sectional growth. A study in Virginia reported that the yearly cross-sectional growth of infected loblolly pines was 4 percent less than the cross-sectional growth of uninfected pines.

In general, the impact of this disease on plantations is greater than on natural stands; its impact on stands on former cropland is greater than on continually forested lands. Losses due to annosus root rot usually begin 2 to 3 years after thinning and increase for the next few years, but generally seem to become stable about 10 years after thinning.

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Figure 4—*Windthrown eastern white pine.*

Site Hazard

In the South, damage to pines is more likely on high-hazard sites, which have sandy or sandy loam soils at least 12 inches (30 cm) deep, good internal drainage, and a low seasonal water table.

Figure 5 is a generalized map of high-hazard soils in the South. In the black areas, the normal result of infection is mortality. In the gray areas, the normal result of infection is growth loss.

Whether these hazard-site categories apply to the Northeast is not known.

Control

Before thinning, pine stands in the South should be surveyed to determine the site's susceptibility to annosus root rot. Soil texture and drainage characteristics can be evaluated with soil maps or by onsite examination of the soil with an auger. On high-hazard sites, preventive control measures should be taken.

The relationship between thinning and subsequent infection has focused attention on the possibility of treating stumps to prevent or control annosus root rot. A number of chemicals have been tested for treating stumps. Dry granular borax has proved to be the most successful chemical for use in the South and Northeast. Immediately after the tree is cut, borax powder is sprinkled liberally on the stump surface with a saltshaker-type applicator (fig. 6).

However, stump treatments with borax are not recommended in stands where annosus root rot is already present; in fact, borax may prevent natural competitors from entering the stump. In such cases, a competing fungus, *Phlebia gigantea* (Fr.) Donk (= *Peniophora gigantea* (Fr.)

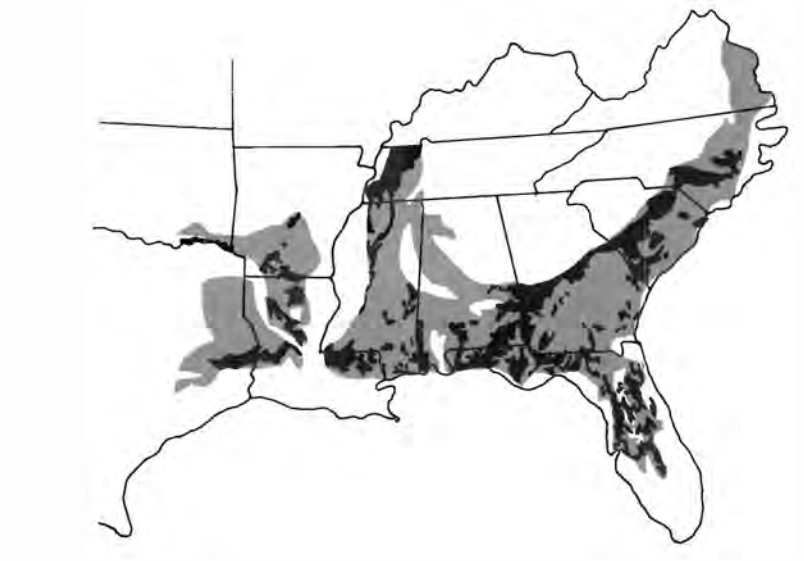

Figure 5—*Generalized map of soils in the Southern United States with high hazard for annosus root rot.*

Massee), can be used as a biological control agent by spraying freshly cut stumps with a water suspension of its spores.

In the South, summer thinning can reduce the amount of stump infection and thus reduce subsequent losses in the residual stand. South of latitude 34° N., temperatures at the stump surface are often high enough from May through August to kill *Heterobasidion annosum*. The formation and dispersal of basidiospores are also quite low during this period. Summer thinning, however, is not recommended where southern pine bark beetles are a threat. Moving northward, the "safe" period for thinning decreases; in the Northeast, stump infection probably occurs during the entire year, so preventive methods other than summer thinning should be used.

Since freshly cut stumps are the primary source of new infections, reducing the number of thinnings in a stand growing on a high-hazard site will reduce the incidence of annosus root rot.

Stands with a history of annosus root rot can be planted with pine immediately after harvesting because the disease in the previous stand will usually kill no more than 5 percent of the seedlings in the new stand. As the new stand matures, additional mortality usually results from stand infection associated with thinning operations. Planting at wider spacing reduces the need for thinning. However, in loblolly and slash pine plantations, wider spacing in areas where fusiform rust hazard is high can lead to understocking of stands.

Although all southern pines are susceptible to annosus root rot, longleaf pine apparently is less susceptible and should be considered for planting on appropriate high-hazard sites.

Figure 7 is a decision key that can be used in the South to identify stand hazard and to prescribe prevention and control strategies. In addition to

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Figure 6—*Application of borax to freshly cut stump.*

the key, the following practices will help reduce losses on high-hazard sites:

1. Monitor radial growth for about 10 years after thinning. A significant reduction in radial growth would probably indicate annosus root rot infection and a need for control.

2. Give severely infected stands high priority for harvesting because they are more likely to be attacked by bark beetles.

3. Prescribe burn at least twice before thinning, once in the 6 months preceding the cutting operations. Repeat burning at least once more after thinning. In areas already infected with annosus root rot, prescribed burning reduces the level of infection by reducing the number of conks present on stumps or standing trees.

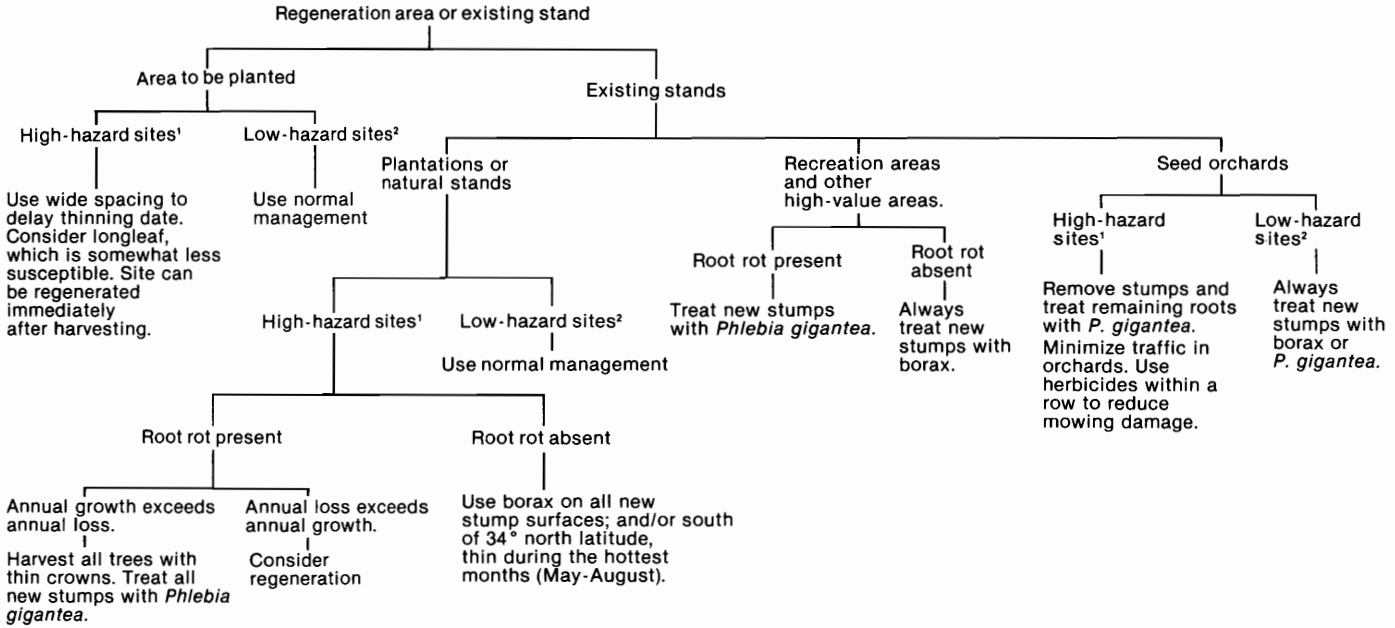
Regeneration area or existing stand
Area to be planted
Existing stands
High-hazard sites[1]
Low-hazard sites[2]
Use wide spacing to delay thinning date. Consider longleaf, which is somewhat less susceptible. Site can be regenerated immediately after harvesting.
Use normal management
Plantations or natural stands
Recreation areas and other high-value areas.
Seed orchards
High-hazard sites[1]
Low-hazard sites[2]
Root rot present
Root rot absent
Treat new stumps with Phlebia gigantea.
Always treat new stumps with borax.
Remove stumps and treat remaining roots with P. gigantea. Minimize traffic in orchards. Use herbicides within a row to reduce mowing damage.
Always treat new stumps with borax or P. gigantea.
High-hazard sites[1]
Low-hazard sites[2]
Use normal management
Root rot present
Root rot absent
Annual growth exceeds annual loss.
Annual loss exceeds annual growth.
Harvest all trees with thin crowns. Treat all new stumps with Phlebia gigantea.
Consider regeneration
Use borax on all new stump surfaces; and/or south of 34° north latitude, thin during the hottest months (May-August).

Figure 7—*Decision key.*

[1] Includes soils with sandy loam textures to a depth of 12 inches (30 cm) or more without poor internal drainage or high seasonal water table.
[2] Includes all soils with poor internal drainage or high seasonal water tables. Also includes well-drained sites where heavy clay is within 12 inches (30 cm) of the surface.

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Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

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